Variability of Low-Level Temperature Inversions in California: Applying GCM Results to California Air Basins

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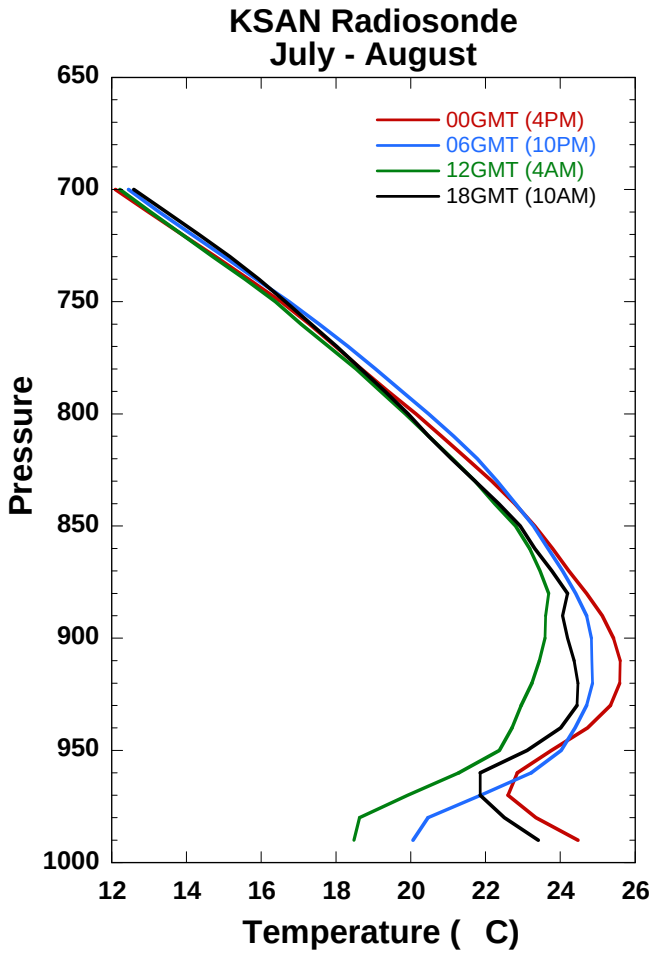


Mean temperature profile at San Diego (KSAN) as a function of time of day.

Outline

1. Numerical models

2. Low-level temperature inversions

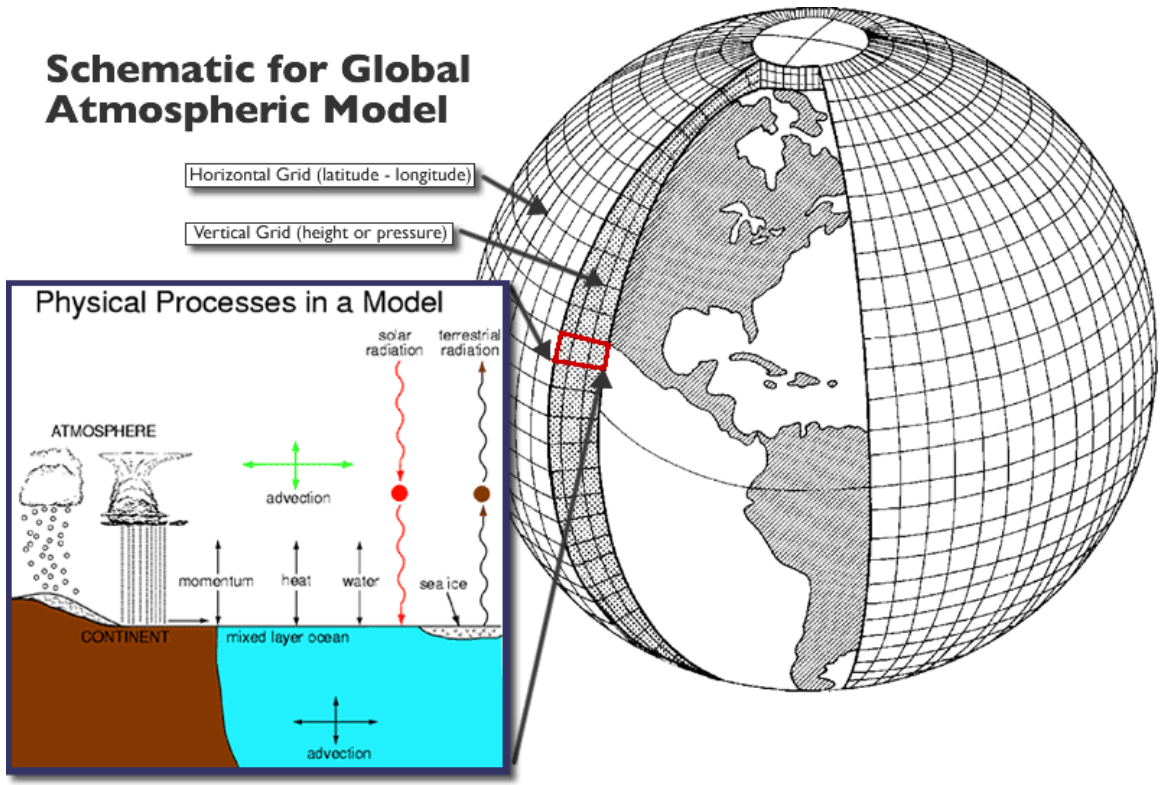
3. Relationship of inversion strength to large-scale and regional-scale circulation

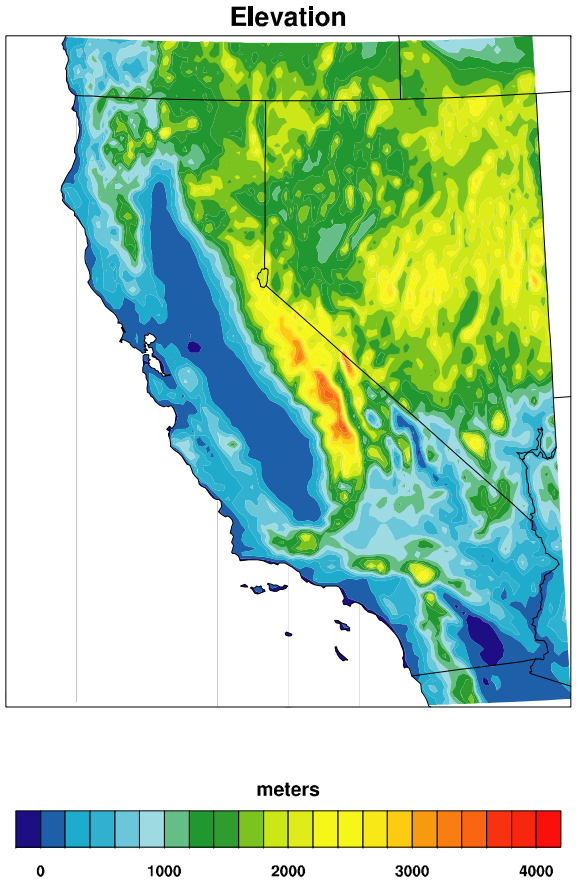
General Circulation Models (GCMs)

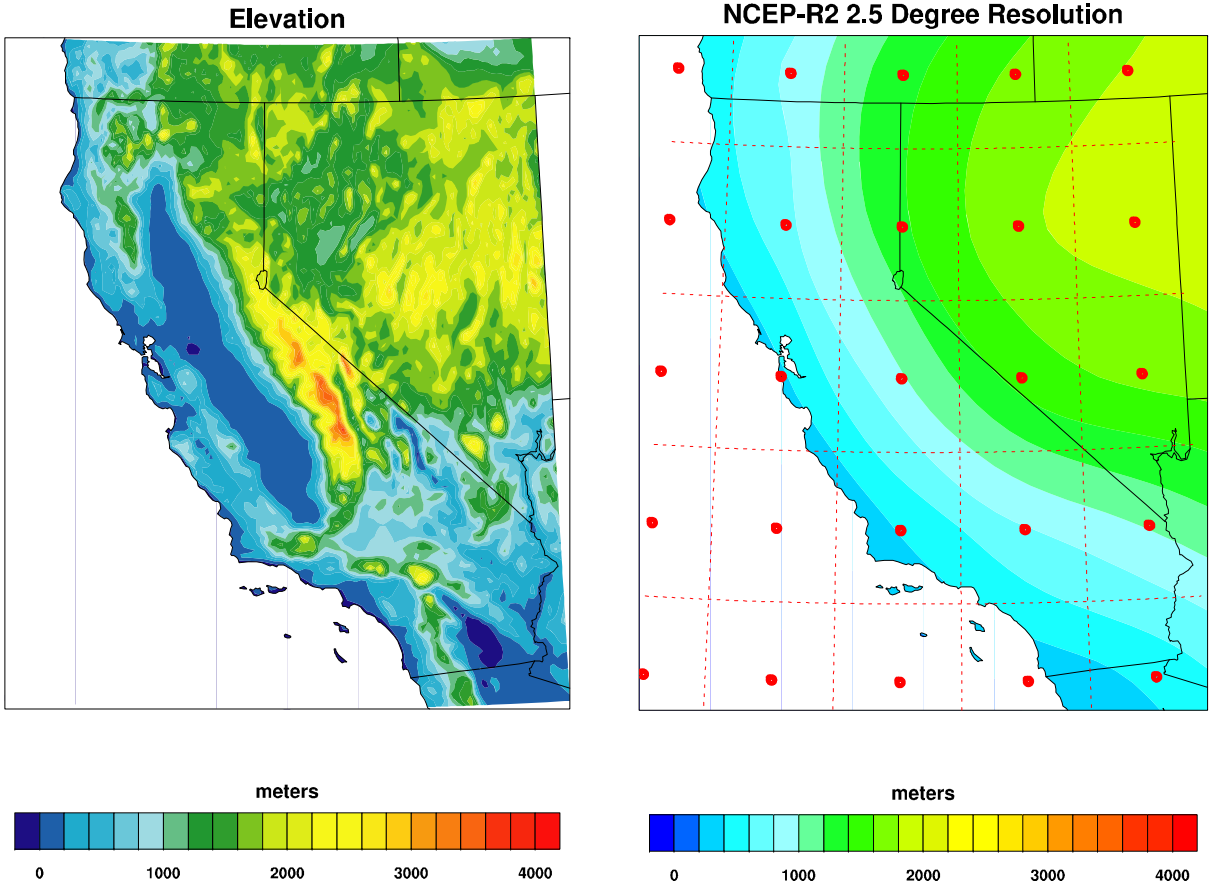
- System of equations describing atmosphere and ocean

- Relatively coarse grid ~2.5° x 2.5°

- Models used to make future global climate predictions (IPCC report)




Elevation
meters
0
1000
2000
3000
4000


Elevation
meters
0
1000
2000
3000
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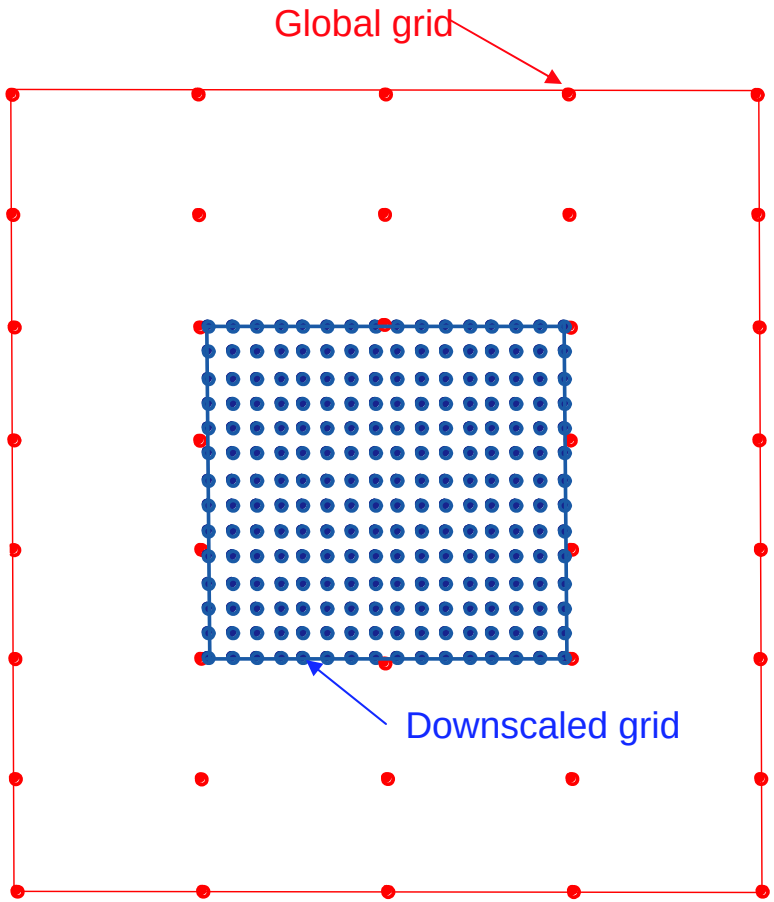
NCEP-R2 2.5 Degree Resolution
meters
0
1000
2000
3000
4000

Downscaling

- Provide increased horizontal and vertical resolution

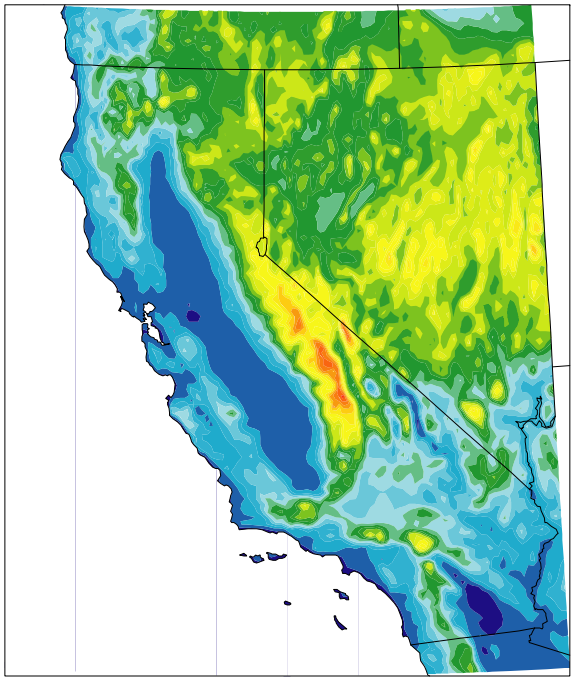
- Regional instead of global

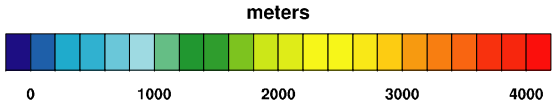
- Use coarse global model results as boundary conditions



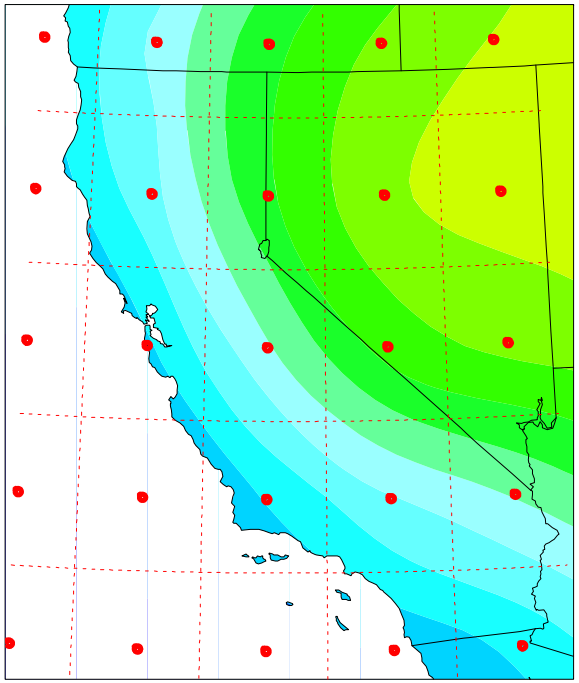
Regional Dynamical Model at Scripps: CaRD10 - California Reanalysis Downscaling at 10 km
Statistical models also being developed

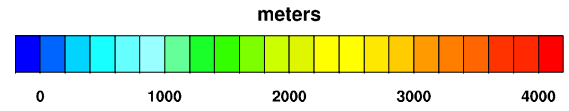
Elevation



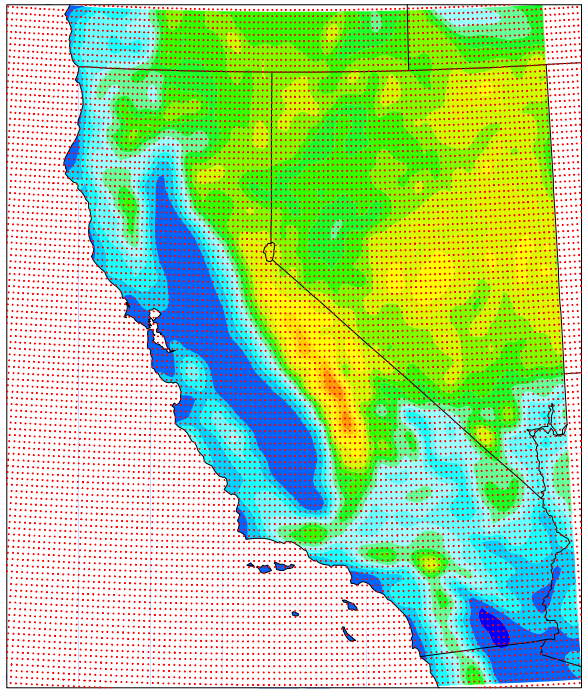


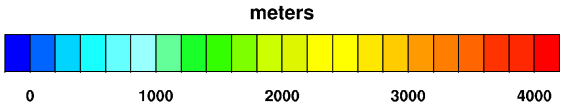
NCEP-R2 2.5 Degree Resolution



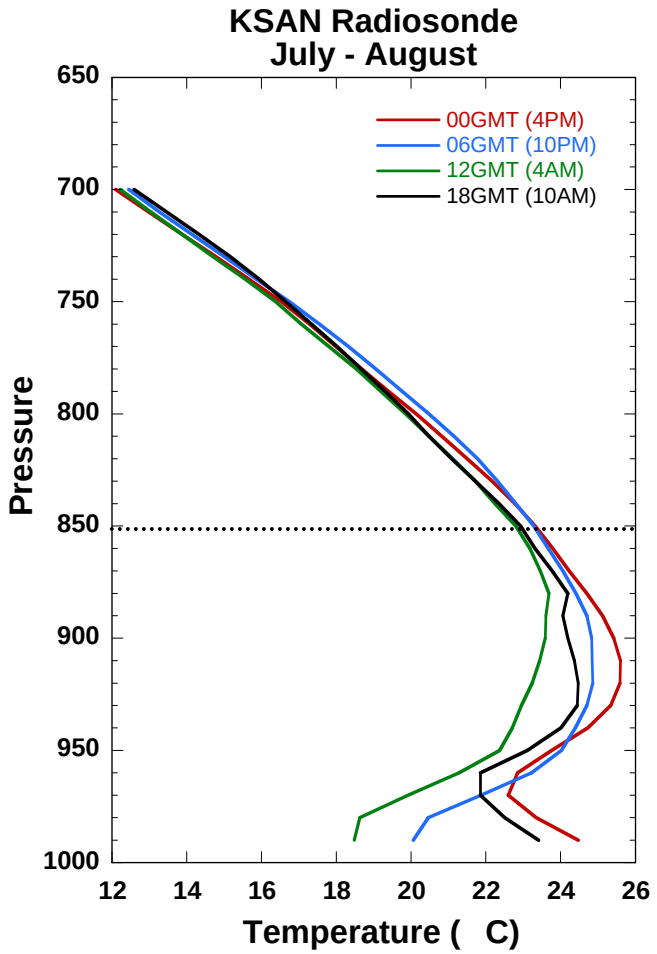


CaRD10 10 km Resolution





Temperature Inversions



Mean temperature profile at San Diego as a function of time of day.

Temperature Inversions

Possible Measures:

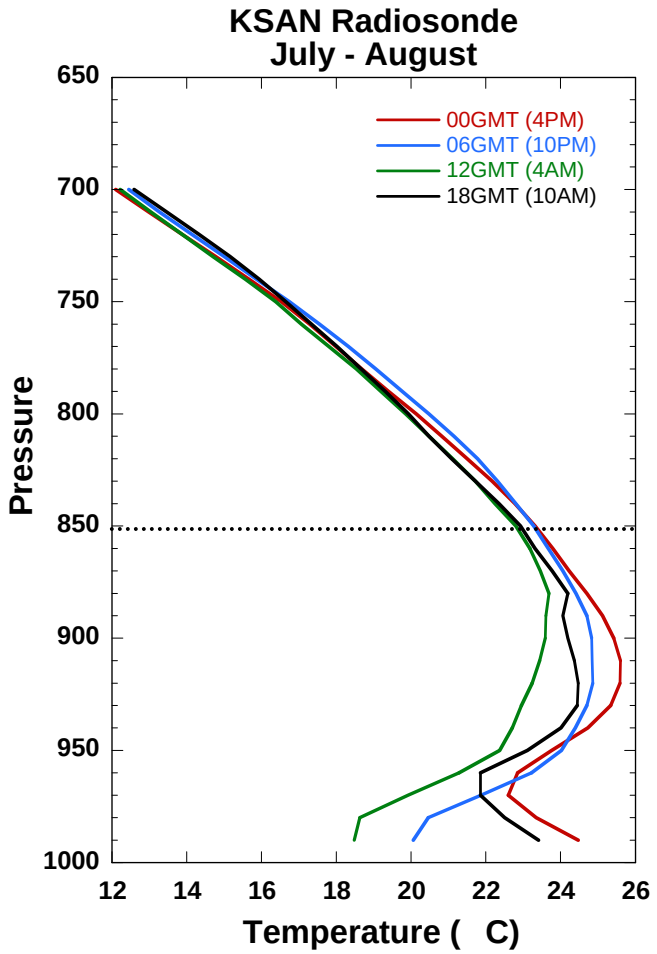
DTINV = T_{top} - T_{base}

DT850 = T850 - T_{2m}

T850 = Temperature at 850 mb

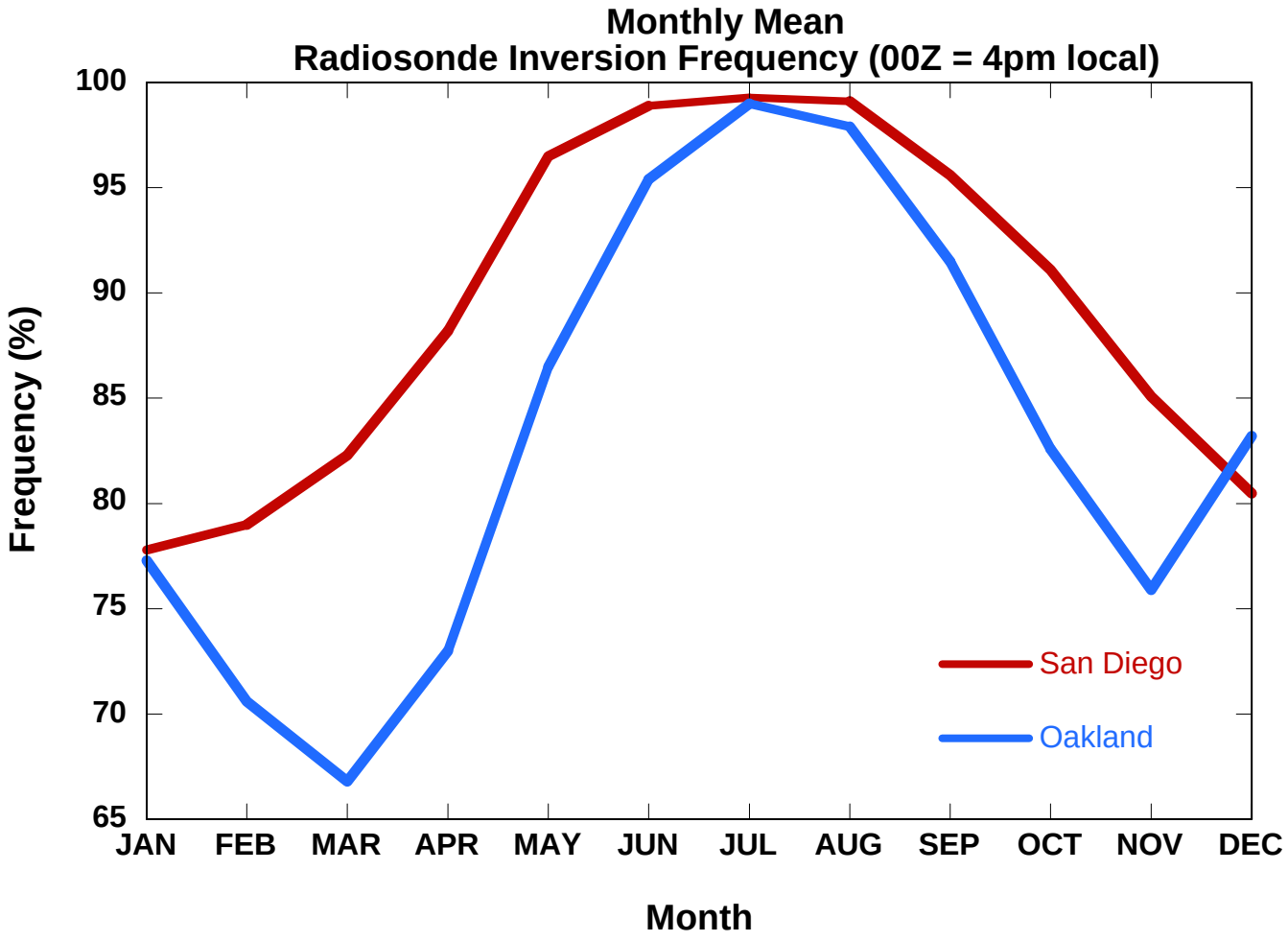
DTDZ = lapse rate within inversion

PBASE = Inversion base pressure

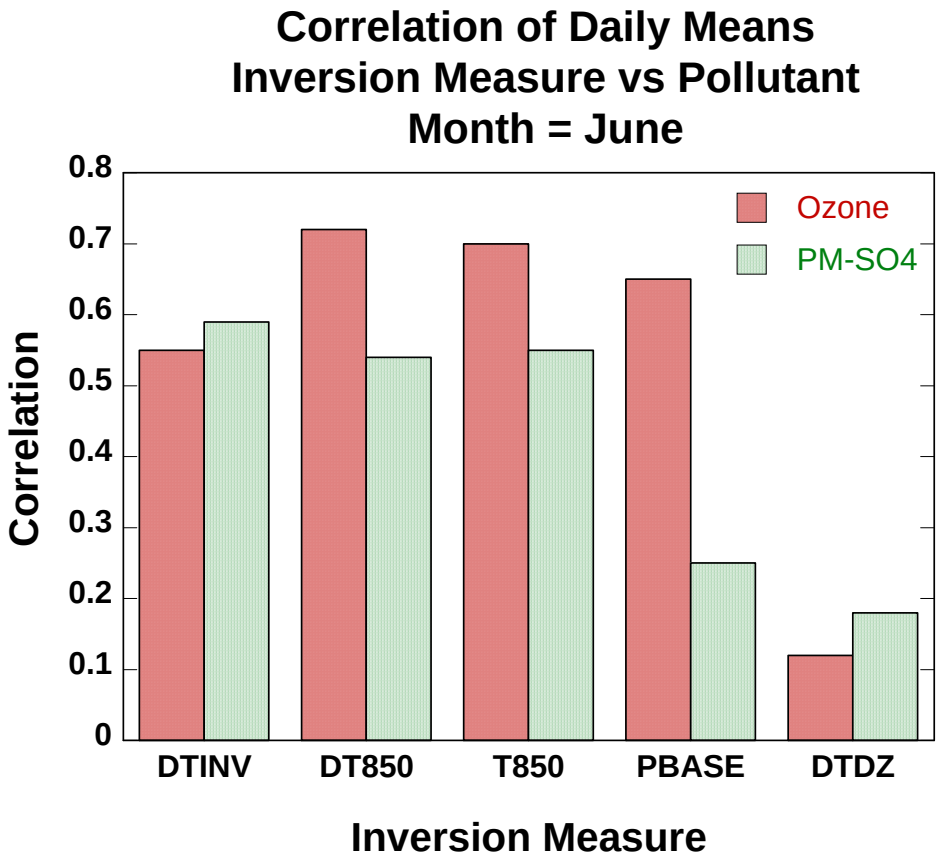


Mean temperature profile at San Diego as a function of time of day.

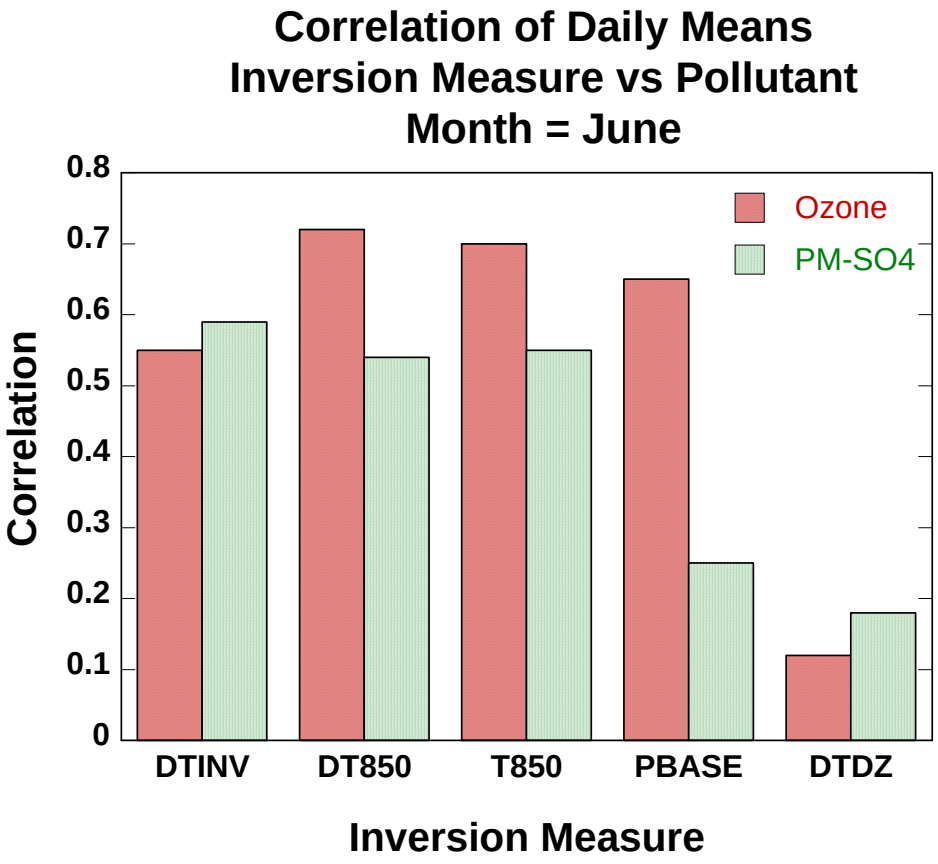
Inversions vary seasonally, but are a dominant feature in California air basins

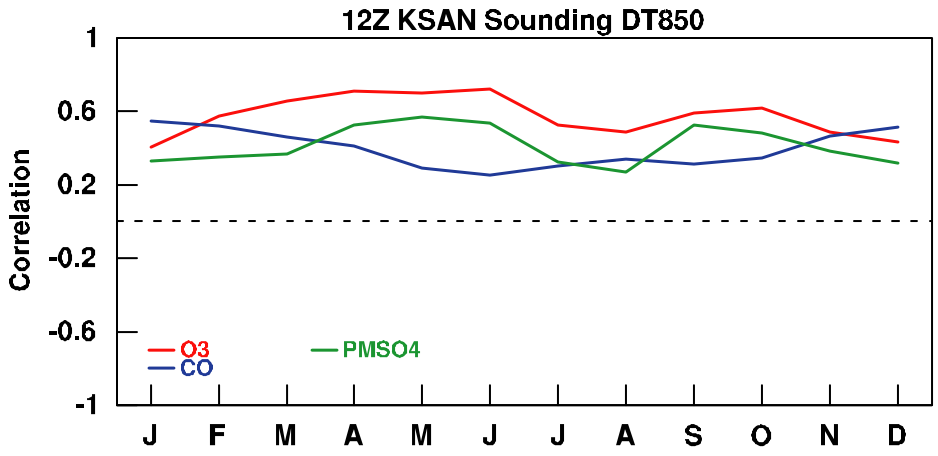


Temperature inversions and pollution



Temperature inversions and pollution





Relationship of inversion strength to large-scale and regional-scale circulation

Model data from:

- NCEP Reanalysis 2 (2.5° x 2.5°)
  - similar resolution to most climate models
  - hindcast
  - incorporates available observations
  - represents best estimate of atmospheric state 1979-present

- California Reanalysis Downscaling at 10km (CaRD10)
  - dynamical downscaling

Composite Daily Atmospheric Patterns During Strong/Weak Inversion Events

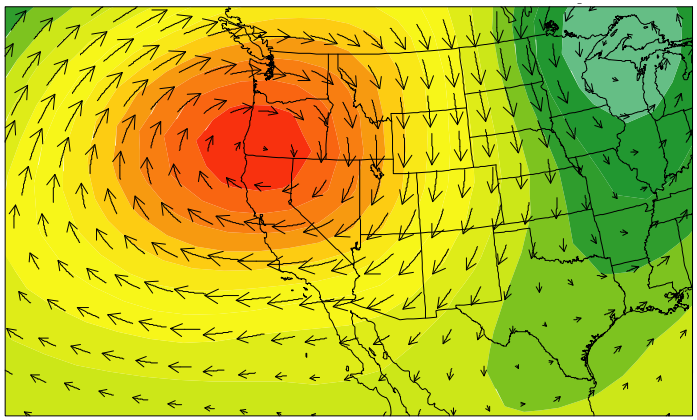
- examine weather balloon data at Oakland (Jun-Aug 1979-2001)

- find the 30 events with largest/smallest inversion magnitudes

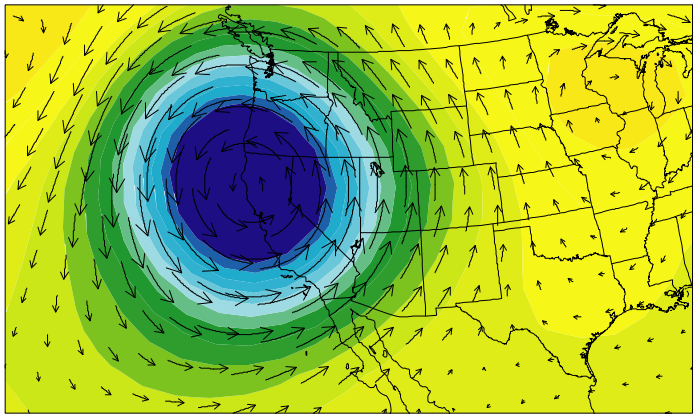
- examine mean large-scale circulation for these 30 events

- consider anomalies (departure from long-term average)

500mb Height and Wind Anomalies



Strong Inversions
at Oakland



Weak Inversions
at Oakland

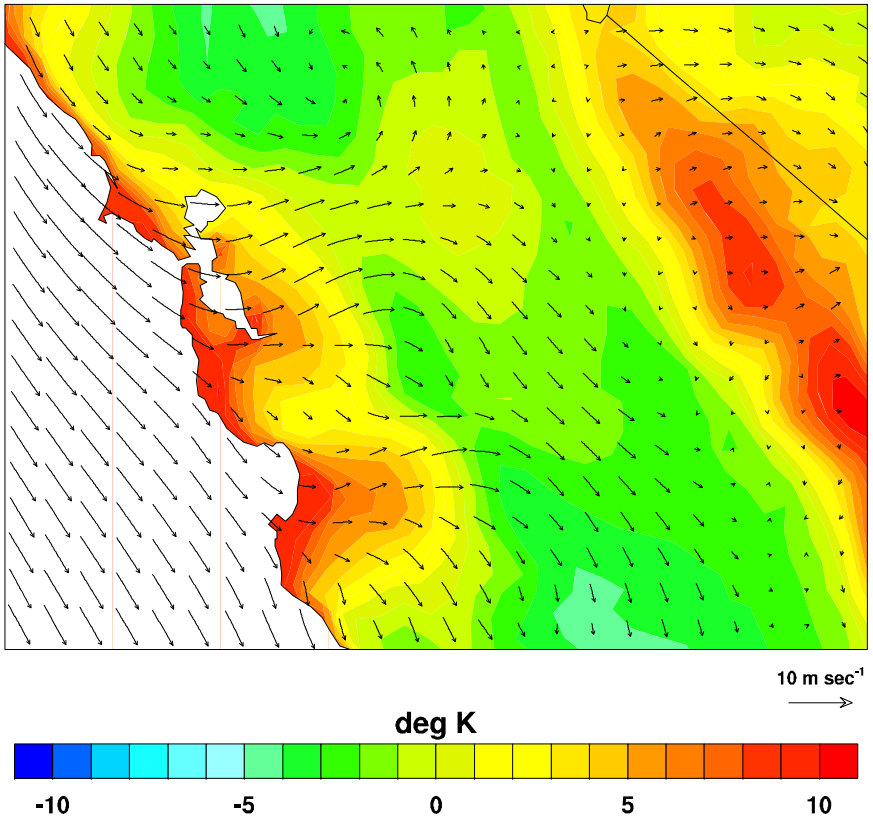
- Strong inversions associated with above normal 500mb heights (large-scale high pressure systems)

- Weak inversions associated with below normal 500mb heights (large-scale low pressure systems)

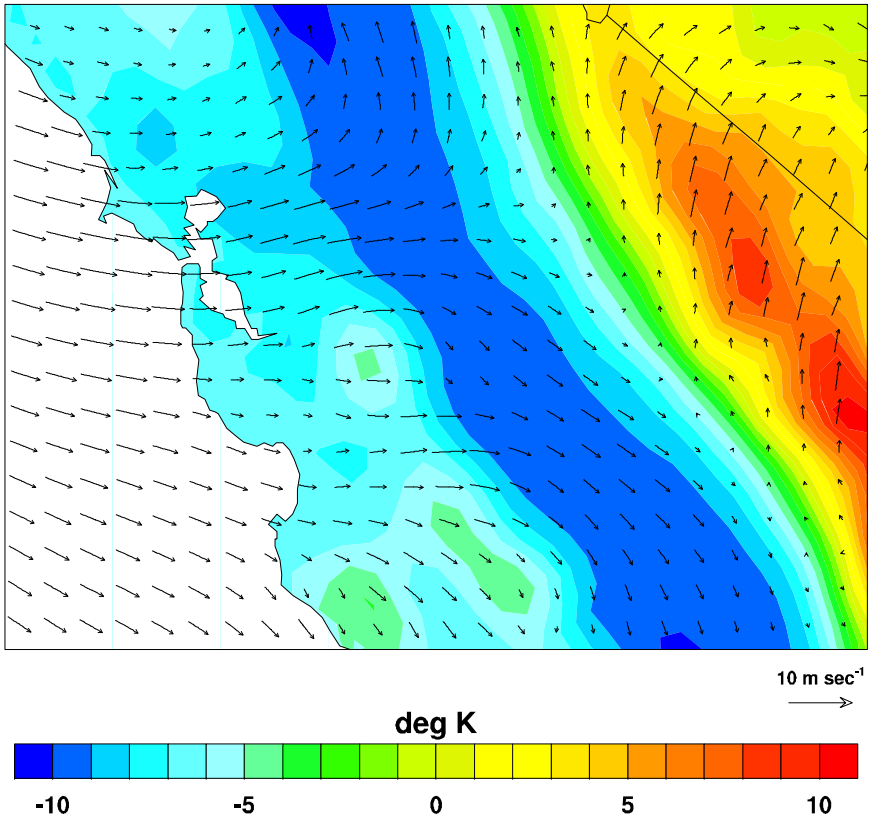
===> Inversions in California associated with large-scale circulation

DOWNSCALED COMPOSITE MEANS JUN-AUG
SURFACE WIND AND INVERSION MAGNITUDE
ACTUAL VALUES (NOT ANOMALIES)

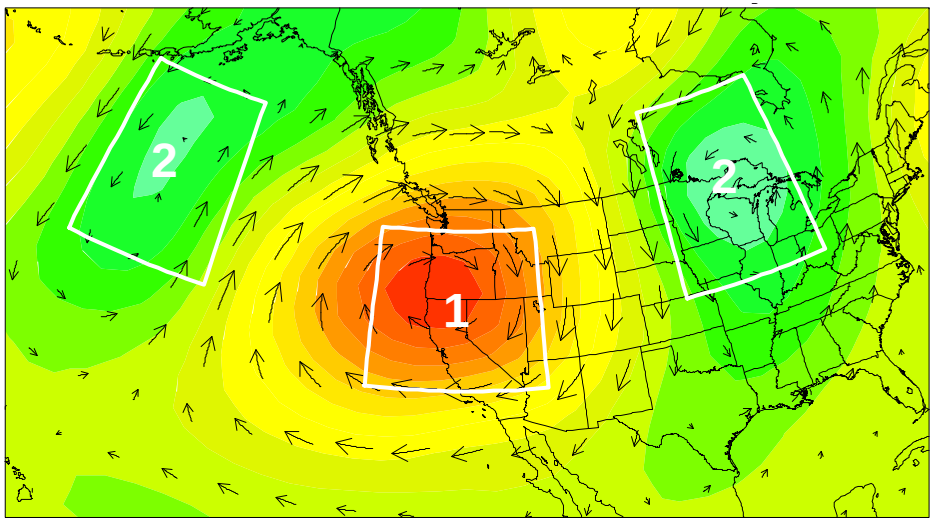
STRONG INVERSIONS AT OAKLAND



WEAK INVERSIONS AT OAKLAND



Large-Scale 500mb Height Difference



Define DH500 = $H_{500,reg1}$ - $H_{500,reg2}$ using historical analysis data

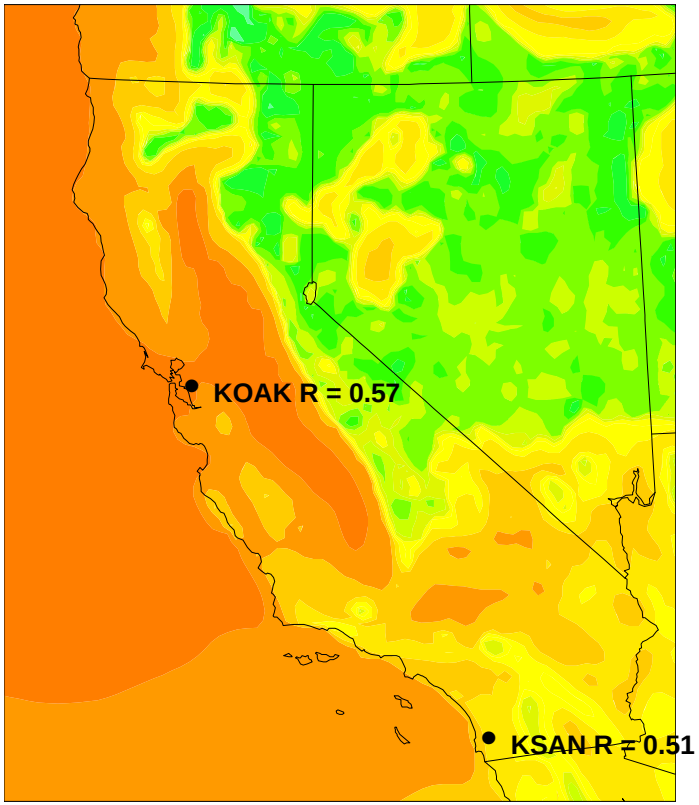
How does this large-scale variable relate to local inversion measures in throughout California? On daily timescales? Monthly timescales?

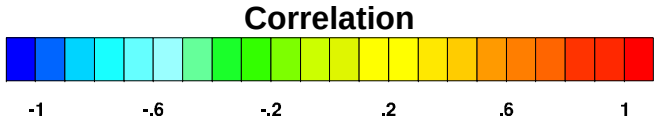
HOW DO LOCAL INVERSION MAGNITUDES COMPARE TO LARGE-SCALE FEATURES?

CORRELATION OF DAILY MEANS

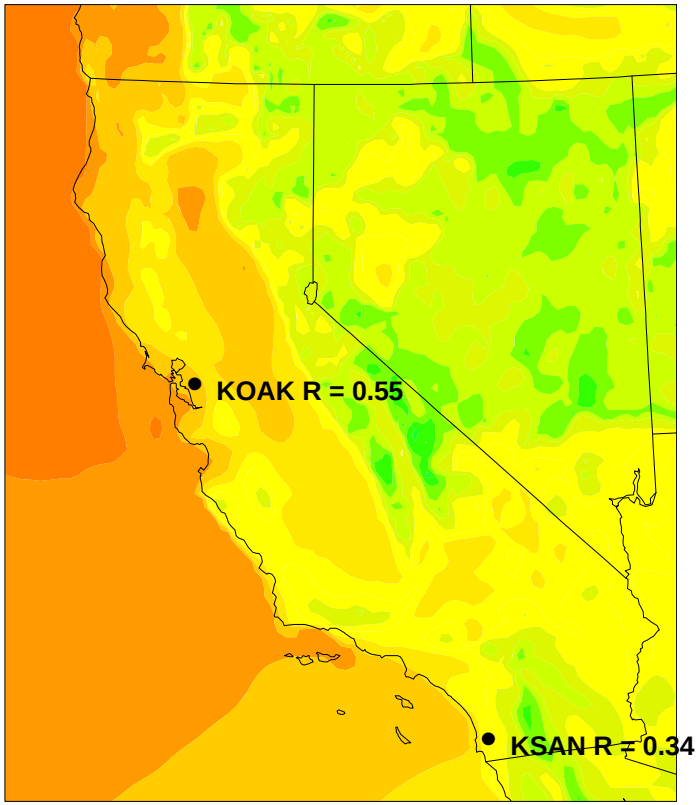
Downscaled Inversion Magnitude vs. Large-Scale 500mb Height Difference

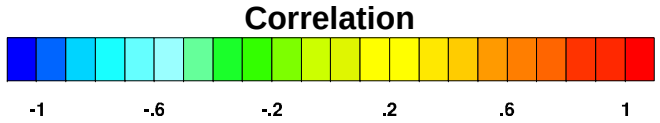
MAR-APR-MAY 1979-2005





JUN-JUL-AUG 1979-2005





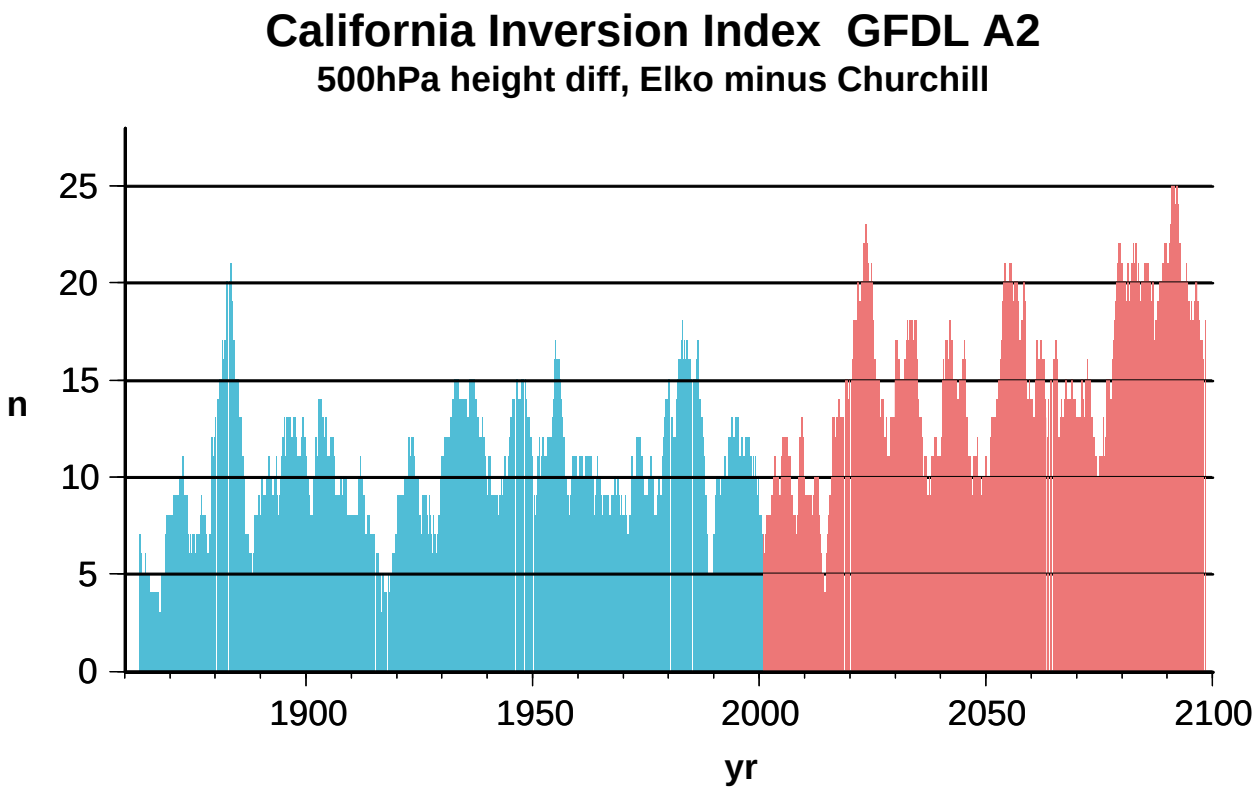


Figure 9. Frequency (5-year running total) of positive ^{2} h500 anomalies exceeding 1.0 standard deviations from the SRES A2 runs of the GFDL CM2.1 model. Here ^{2}h 500 is defined as the difference in 500 mb height between 42°N, 115°W (Elko) and 60°N, 95°W (Churchill). The anomalies are referenced to the 1961-1990 climatology.

Summary

- Low-level temperature inversions are a consistent feature in California air basins as evidenced at San Diego and Oakland (additional soundings at inland sites currently being examined).

- Inversion measures using temperature at top or across inversion show higher correlation to pollution.

- Inversion intensity is strongly linked to large-scale circulation features (e.g., CA Central Valley during Spring). This large-scale structure should allow us to downscale GCM simulations to California air basins.

- Climate change simulations provide large-scale structure that may allow us to project trends of inversion magnitudes and frequencies.

Future Work

- Continue to collect and analyze atmospheric soundings
- Produce more quantitative products relating large-scale circulation to inversion characteristics for California air basins
- Examine how inversion frequency/magnitude related to warm/cold periods in historical record
- Investigate role of decadal climate modes and ENSO on circulation patterns and inversion characteristics
- Use GCM climate simulations and downscaling to examine potential changes in low-level inversions.